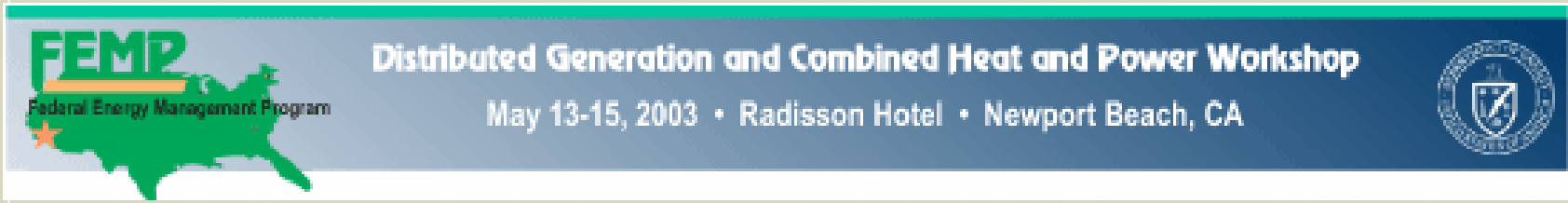
# A Powerful Opportunity

## FuelCell Energy's On-site Power Generation Solutions –

## A Near Zero Emissions Technology Available Today



# Agenda

- Introduction – FuelCell Energy
- Fuel Cell Power Generation Technologies
  - Advantages of Direct FuelCell® Technology
  - CHP Applications
- Benefits of Direct FuelCell® Technology and Target Markets
- Challenges and Opportunities

# Who is FuelCell Energy?

- A leading fuel cell technology developer for over 30 years
- Headquarted in Danbury, CT; Manufacturing Facilities in Torrington, CT
- 425 Employees; 160 new hires in 2002
- Over $400 million invested in fuel cell technology development
- Manufacturing, testing and conditioning facility expanded to accommodate over 50 MW
- Going to market now with advanced Direct FuelCell® technology
- Over 10 million kWh generated to date; 7 million kWh at customer sites

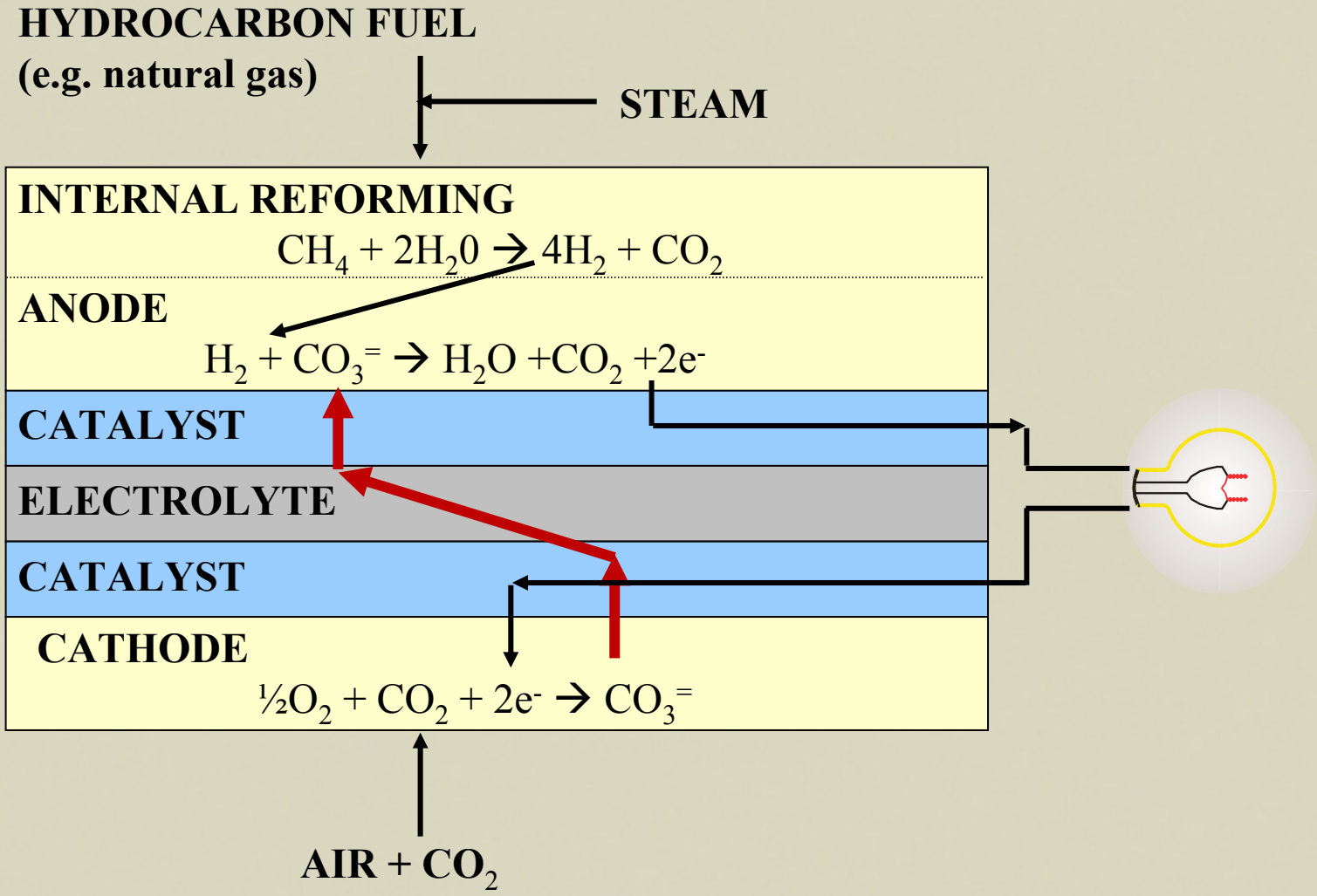
# Fuel Cell Power Generation Technologies

## Advantages of Direct FuelCell®

# Fuel Cell Stationary Power Generation Offerings

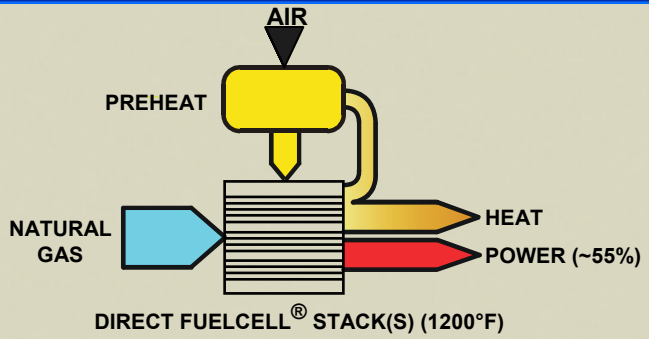
| | Fuel Cell Type | | | |
|---|---|---|---|---|
| | **Polymer Electrolyte Membrane** | **Phosphoric Acid** | **Carbonate Direct Fuel Cell®** | **Solid Oxide** |
| **Electrolyte** | Ion Exchange Membrane | Phosphoric Acid | Alkali Carbonate | Yttria Stabilized Zirconia |
| **Operating Temp. °F** | 200 | 400 | 1200 | 1800 |
| **Charge Carrier** | $H^+$ | $H^+$ | $CO_3^=$ | $O^=$ |
| **Cell Hardware** | Carbon /Metal Based | Graphite | Stainless Steel | Ceramic |
| **Catalyst** | Platinum | Platinum | Nickel | Perovskites |

# Direct FuelCell® - Hydrogen Benefits Without External Reforming

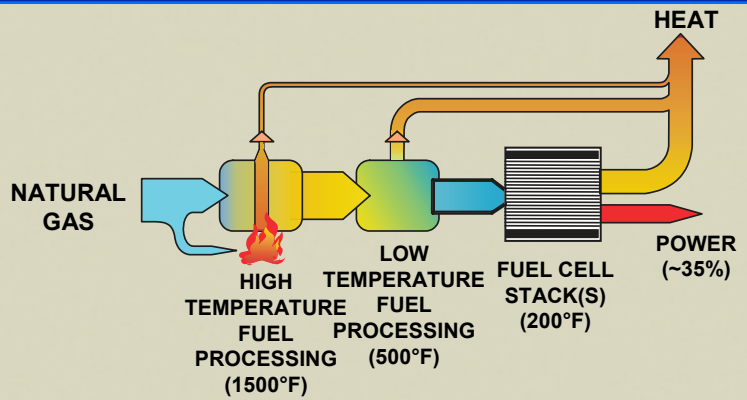


# Direct FuelCell® Technology Advantage

**High Temperature Internal Reforming Direct FuelCell®**

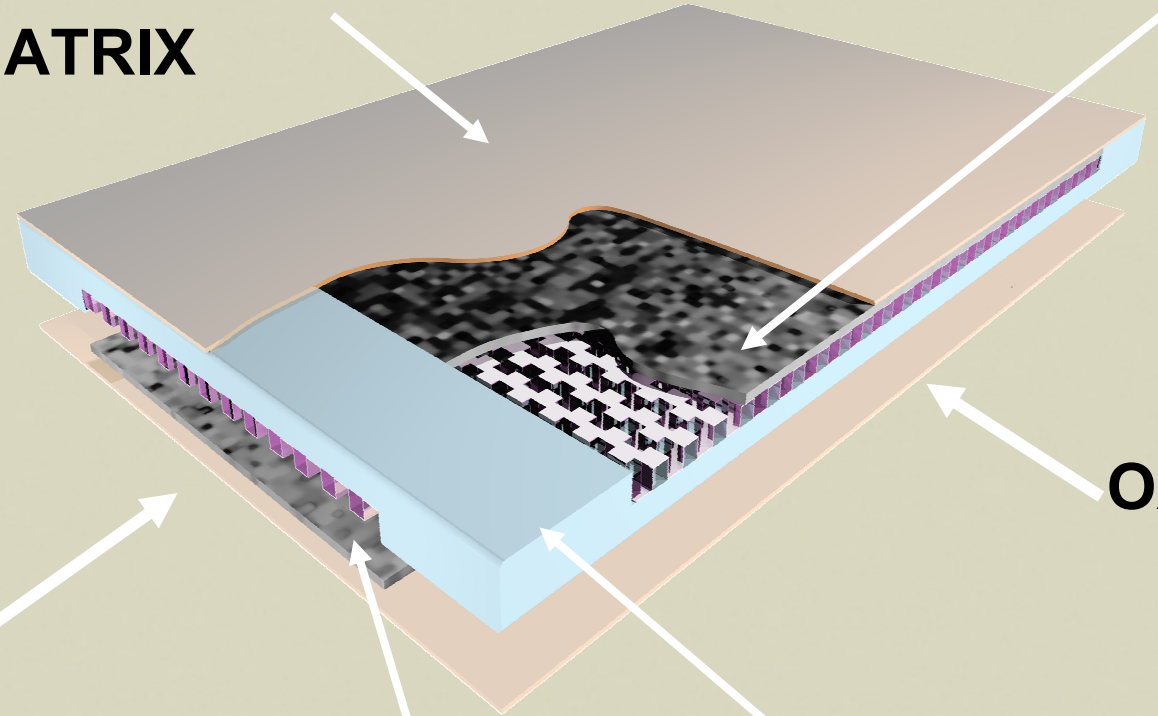



**Low Temperature External Reforming Fuel Cell**




- **Optimal Operating Temperature**
  - Uses commonly available materials
  - No noble metal catalyst
  - High temperature by-product heat
- **Internal Reforming**
  - High electrical efficiency (47%)
  - Simpler system
  - Negligible $NO_X$
  - Reduced cooling requirement
- **Atmospheric Pressure Operation**
  - Allows unattended operation
  - More reliable

# Direct FuelCell® Components



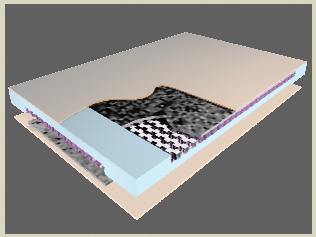
# FuelCell Energy Products

- Building block approach provides scalability and a standardized product to manufacture

Sub-MW Power Plant

Sub-MW Module

Stack



Fuel Cell

MW Module

MW Power Plant

# FuelCell Energy Current Products – 250kW-10MW

DFC® 300


DFC® 1500

DFC® 3000

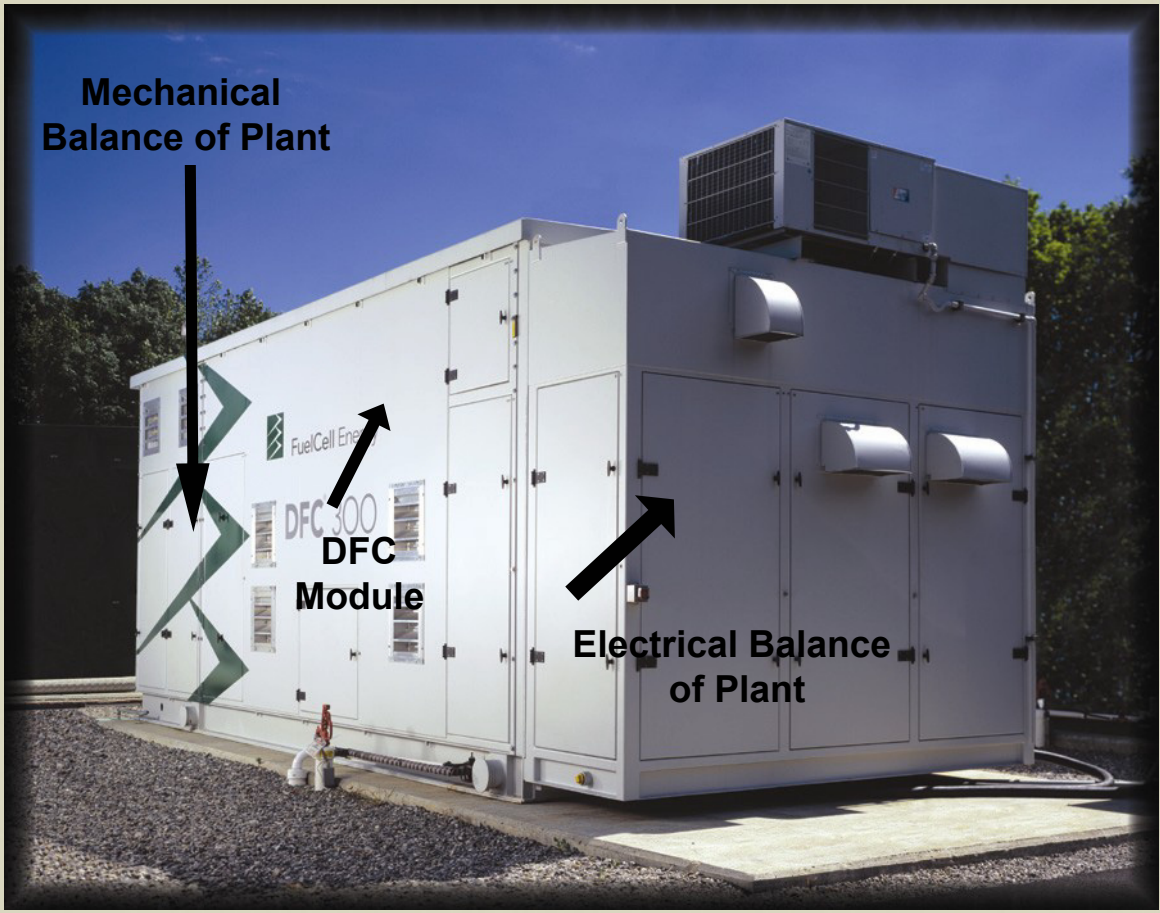
## Product Characteristics

- High temperature, carbonate fuel cell power plants for base load commercial and industrial applications
- High electrical efficiency
- High value waste heat by-product for cogeneration
- Internally generated hydrogen from readily available fuels such as natural gas – operating at customer sites today

Multi-MW Grid Support

# DFC®300 Layout

| | DFC®300 |
|---|---|
| Length (ft) | 28.0 |
| Width (ft) | 10.5 |
| Height (ft) | 11.0 |
| Footprint ($ft^2$) | 294 |
| Weight | 43 tons |



# DFC®1500 Layout

# DFC®1500

| | | DFC1500 |
|---|---|---|
| Length (ft) | | 42 |
| Width (ft) | | 39 |
| Footprint Area ($ft^2$) | | 1640 |
| Skids | | 4 |
| Module | 13’ d x 13’ h | 45 tons |
| Fuel/Water Treatment | 36’ x 10’ x 12’ | 45 tons |
| Heat Rec./ IA / Oxidizer | 37’ x 10’ x 12’ | 58 tons |
| EBOP | 20’ x 8.5’ x 11 | 33 tons |

# Net Power & Efficiency (LHV)

| Current Products | DFC®300 | DFC®1500 | DFC®3000 |
|---|---|---|---|
| Power, kW | 250 | 1,000 | 2,000 |
| Efficiency | 47% | 48% | 49% |
| Heat Rate (Btu/kWh) | 7,260 | 7,110 | 6,965 |

| 2005 Products /Restacks | DFC®300 | DFC®1500 | DFC®3000 |
|---|---|---|---|
| Power, kW | 300 | 1,200 | 2,400 |
| Efficiency | 51% | 52% | 53% |
| Heat Rate (Btu/kWh) | 6,690 | 6,565 | 6,440 |

# Plant Operating Characteristics – Design Life

- Design Life - 30 years
- Initial Stack Life - 3 to 5 years (25,000 hours)
- Subsequent Stack Life - 5 years (40,000 hours)
- Economic decision drives restack
- Restack Output – 300, 1500 and 2000 kW
- BOP designed for higher rating
- Initial Output/Efficiency Degradation - 3% per year
- Restack Output/Efficiency Degradation - 2% per year

# DFC Applications – Cogeneration/CHP

**Standard Production Equipment Available**


# Exhaust Heat Output and CHP Production

- Standard exhaust connection
- High grade heat
  - EGT 750°F
- Total Exhaust Heat
  - 585 – 660 MBH (DFC®300)
- Allowable back pressure
  - < 2 inches water column (i.w.c.)

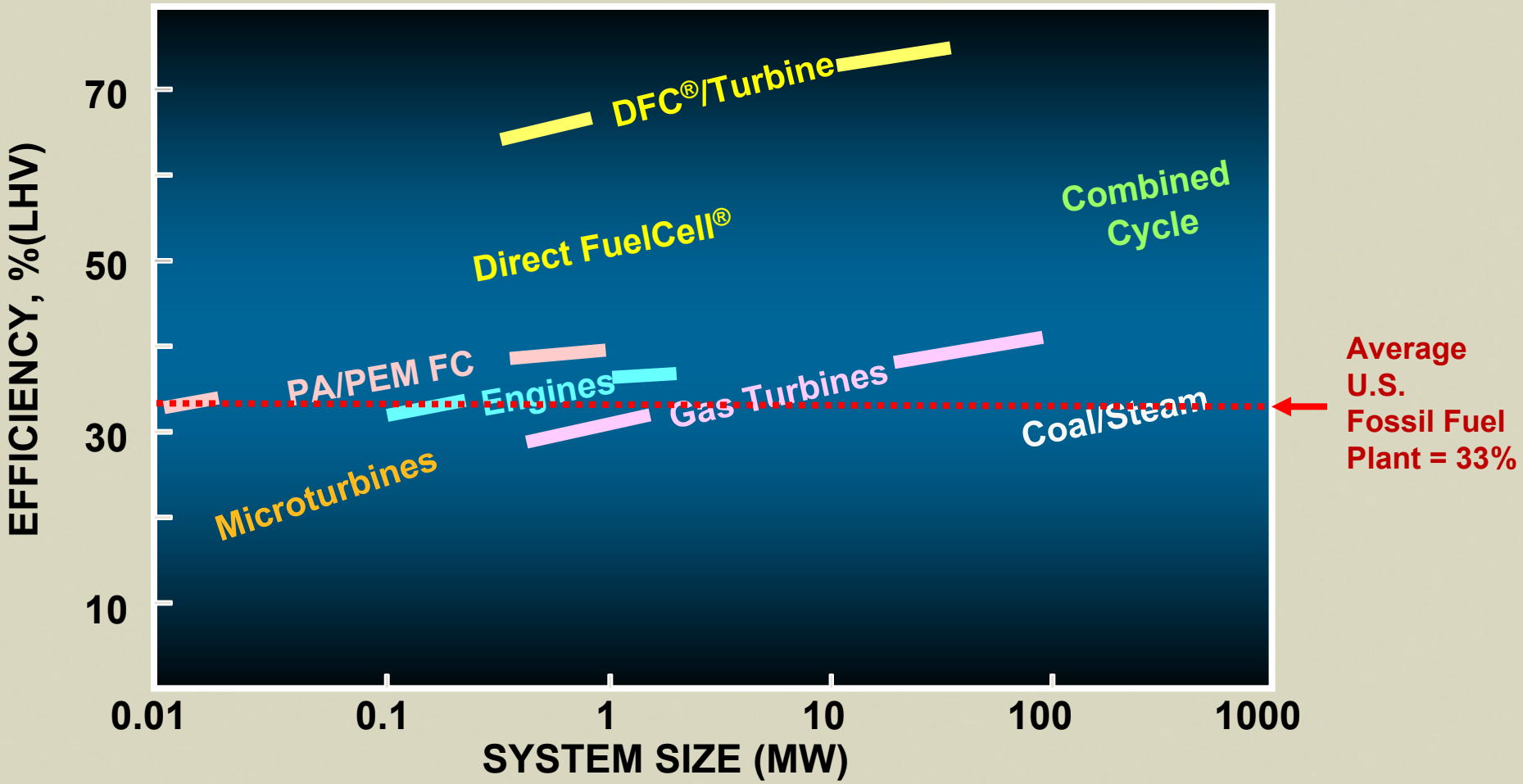
| | DFC®300 | DFC®1500 | DFC®3000 |
|---|---|---|---|
| **Hot Water Btu/hr @ ΔT** | **410,000 @ 20°F** | **1,840,000 @ 100°F** | **3,640,000 @ 70°F** |
| **Steam, pph 15 psig, sat.** | **430** | **1,700** | **3,300** |
| **Chilled Water - tons** | **35** | **160** | **315** |

# DFC Applications - Digester Gas

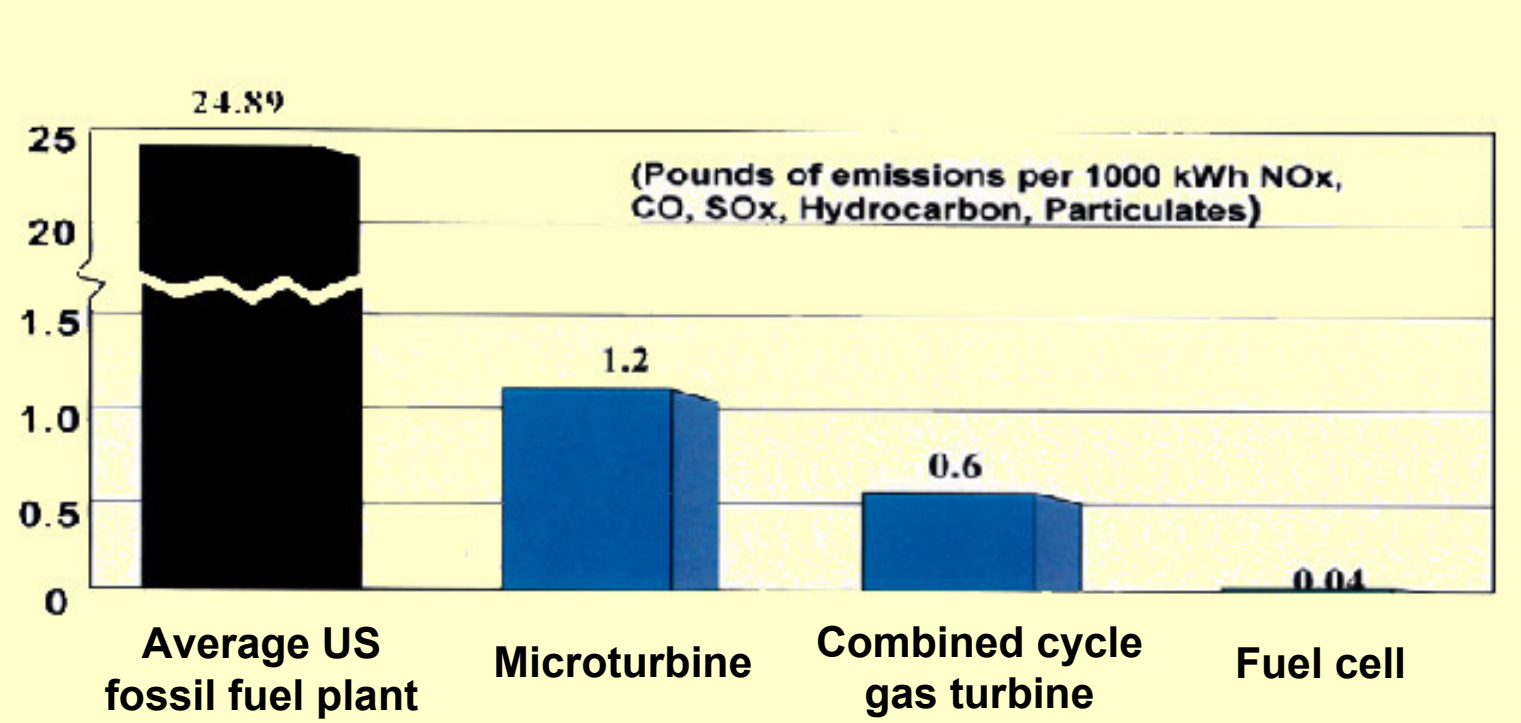
- Digesters treat sewage sludge, animal manure or agricultural waste
- Produce $CH_4$ and $CO_2$
  - ~60-65% $CH_4$
  - ~500-1500 ppm $H_2S$ (sewage)
- Digesters require heat input to maintain optimum temperature (~98 F)

# Benefits of Direct FuelCell® Technology and Target Markets

# Direct FuelCell® Technology Conserves Energy Resources



# Unmatched Emissions Performance of DFC Power Plants

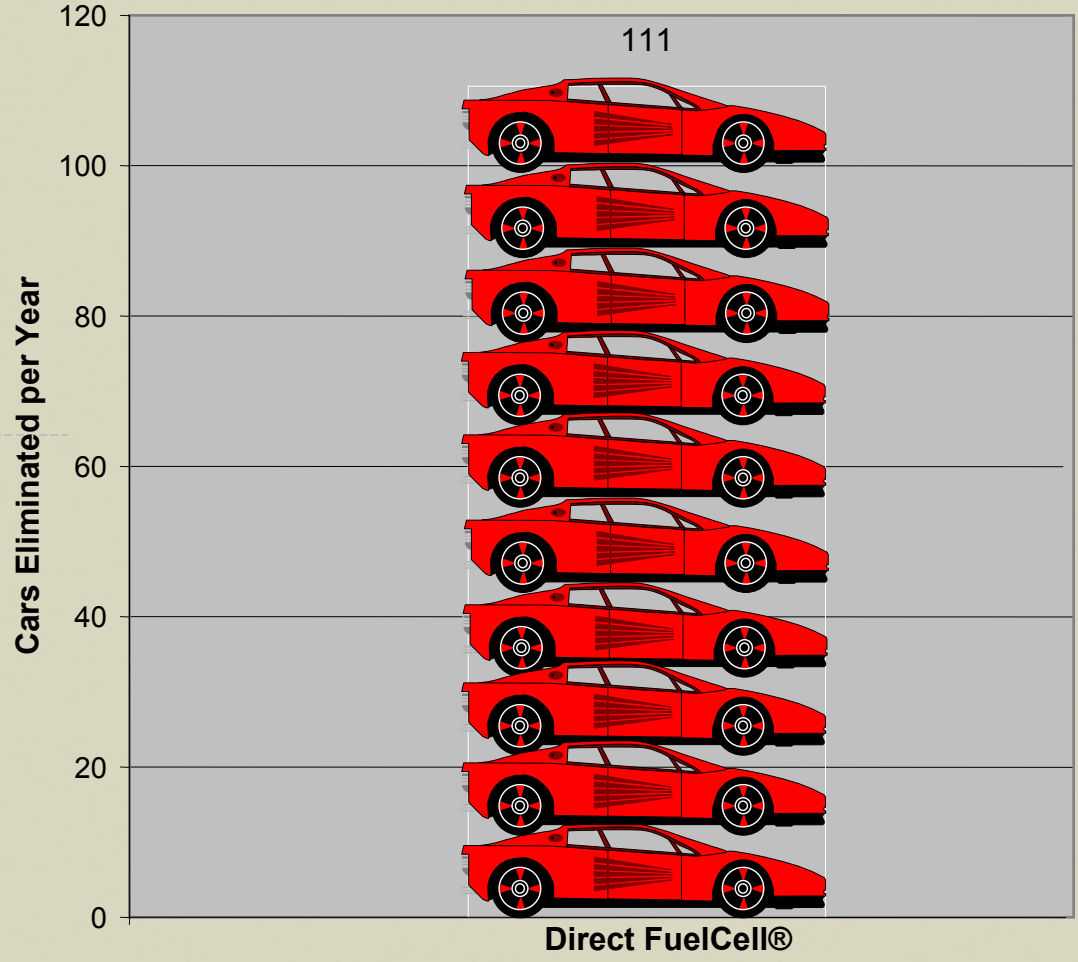



- Fuel cells meet CARB's stringent 2007 emissions standards for DG
  - 0.006 lbs/MW-hr of NOx
  - 0.0007 lbs/MW-hr of SO2
  - 0.0028 lbs/MW-hr of CO

*Source: NETL(http://www.eren.doe.gov/der/pdfs/mid_atlantic_conf_02/williams.pdf)*

# Significant CO2 Emissions Displacement

- A DFC300 power plant displaces CO2 emissions when compared to an average natural gas-fired power plant equivalent to taking over 100 cars off the road
  - CAFE standard automobile efficiency: 27.5 mpg
  - 12,000 miles per year



# Target Customers

- Institutional
  - Hospitals
  - Universities
- Commercial
  - Hotels
  - Data Centers
  - Office/Shopping
- Industrial
  - Waste Water
  - Telecom
  - Food & Beverage
  - Chemical
  - Manufacturing
- Utility
  - Grid-support









# Waste Water Treatment Facilities – A Unique Opportunity

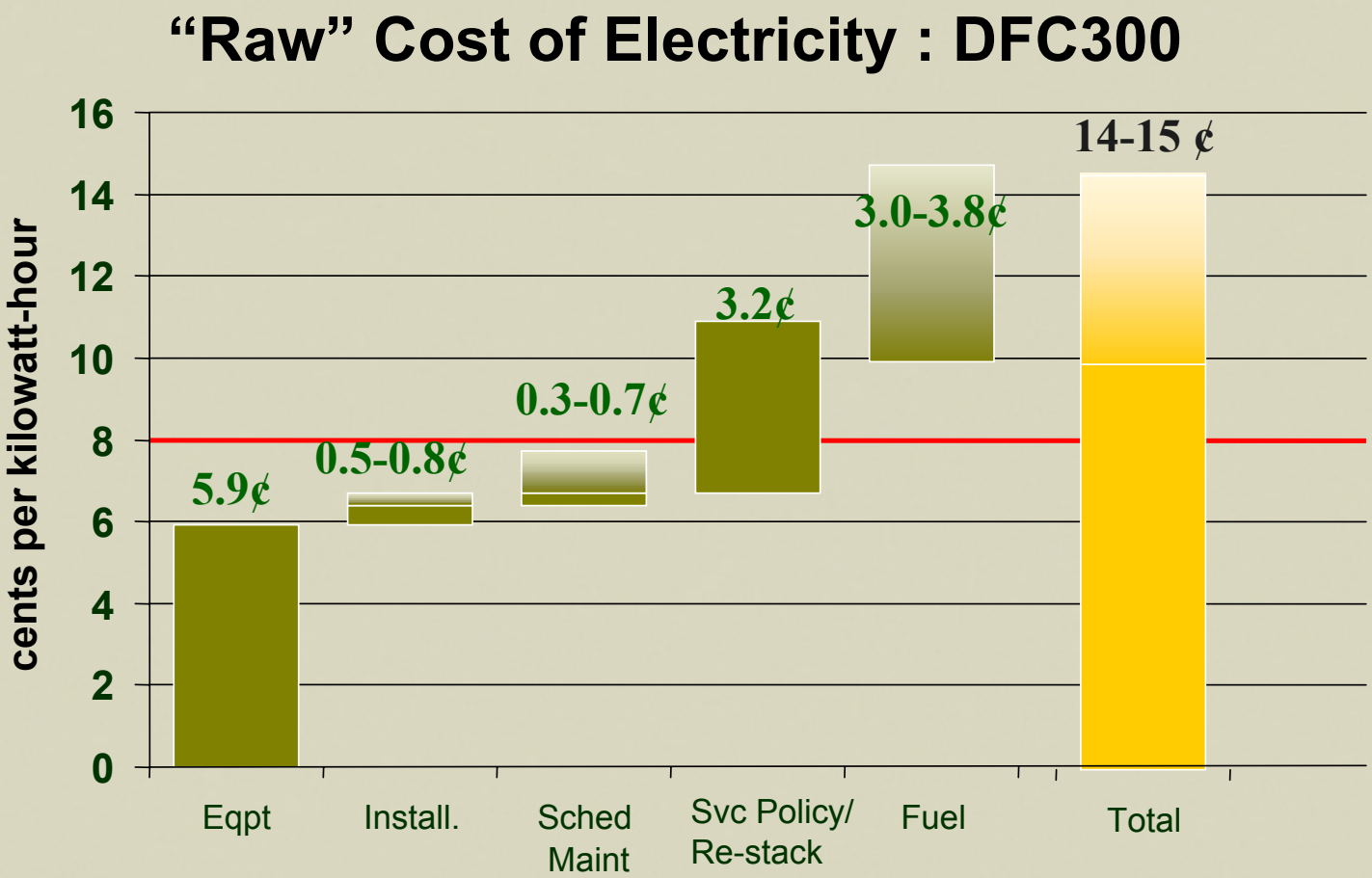
- Uses anaerobic digester gas from industrial and municipal waste water treatment facilities
- Use of "bio" gas makes this a "renewable" application.
- King County. Kirin Brewery and Terminal Island (pictured here)

***Over 500 MW Waste Water Fuel Cell Installations by 2011****

* - Allied Business Intelligence's 2001 Study, *"Stationary Fuel Cells: U.S. and Global Early Market Opportunities."*

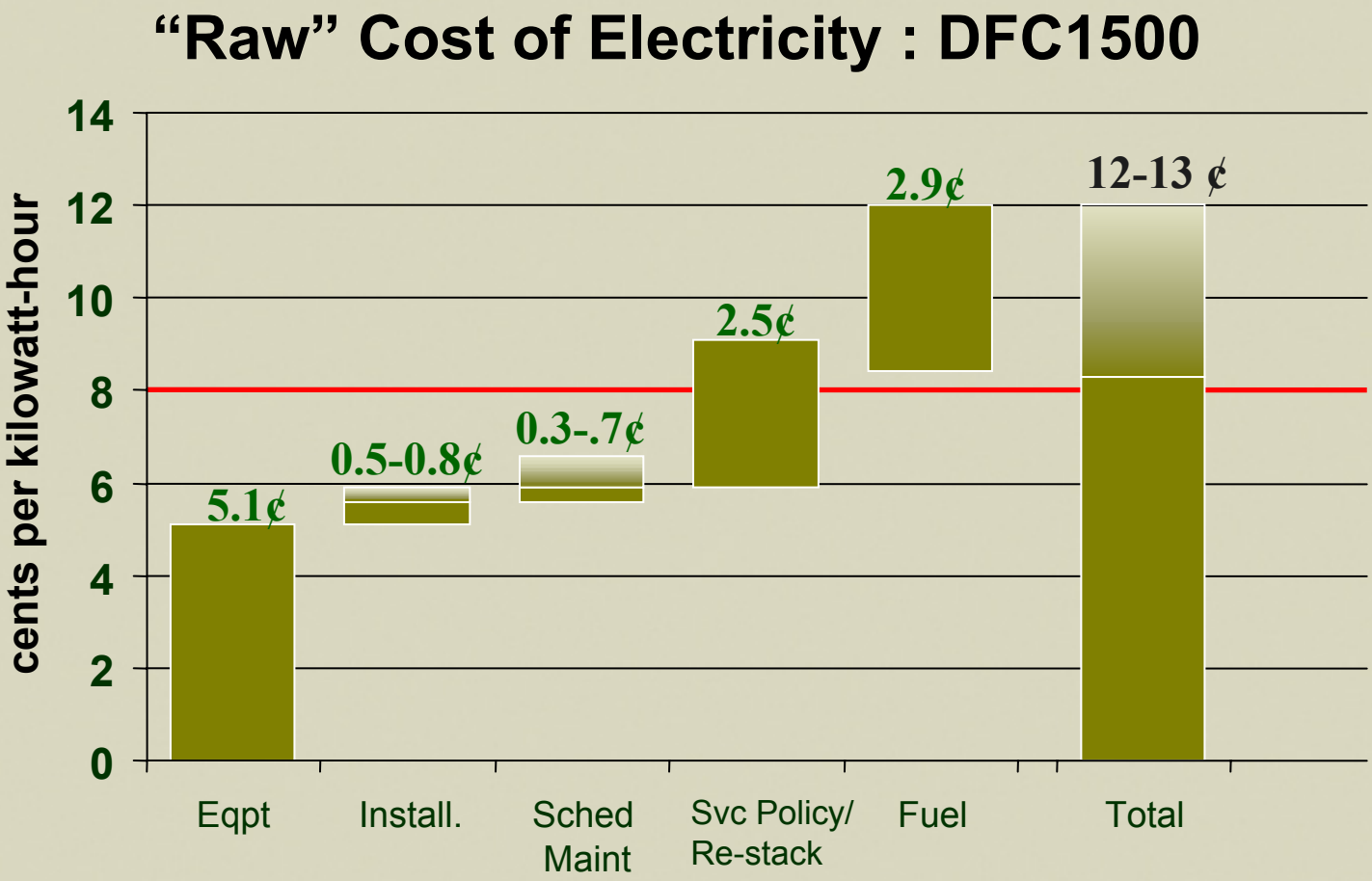
# Challenges and Opportunities

# First Cost Challenge – Biggest Barrier for Fuel Cells Today




- *Cap cost amortized 15 yrs @ 8%*
- *Baseload operation; No value assigned to recovered heat*
- *Fuel cost = $4.00 - $5.00 /MMBtu*

# First Cost Challenge – Size Helps Overcome Barrier

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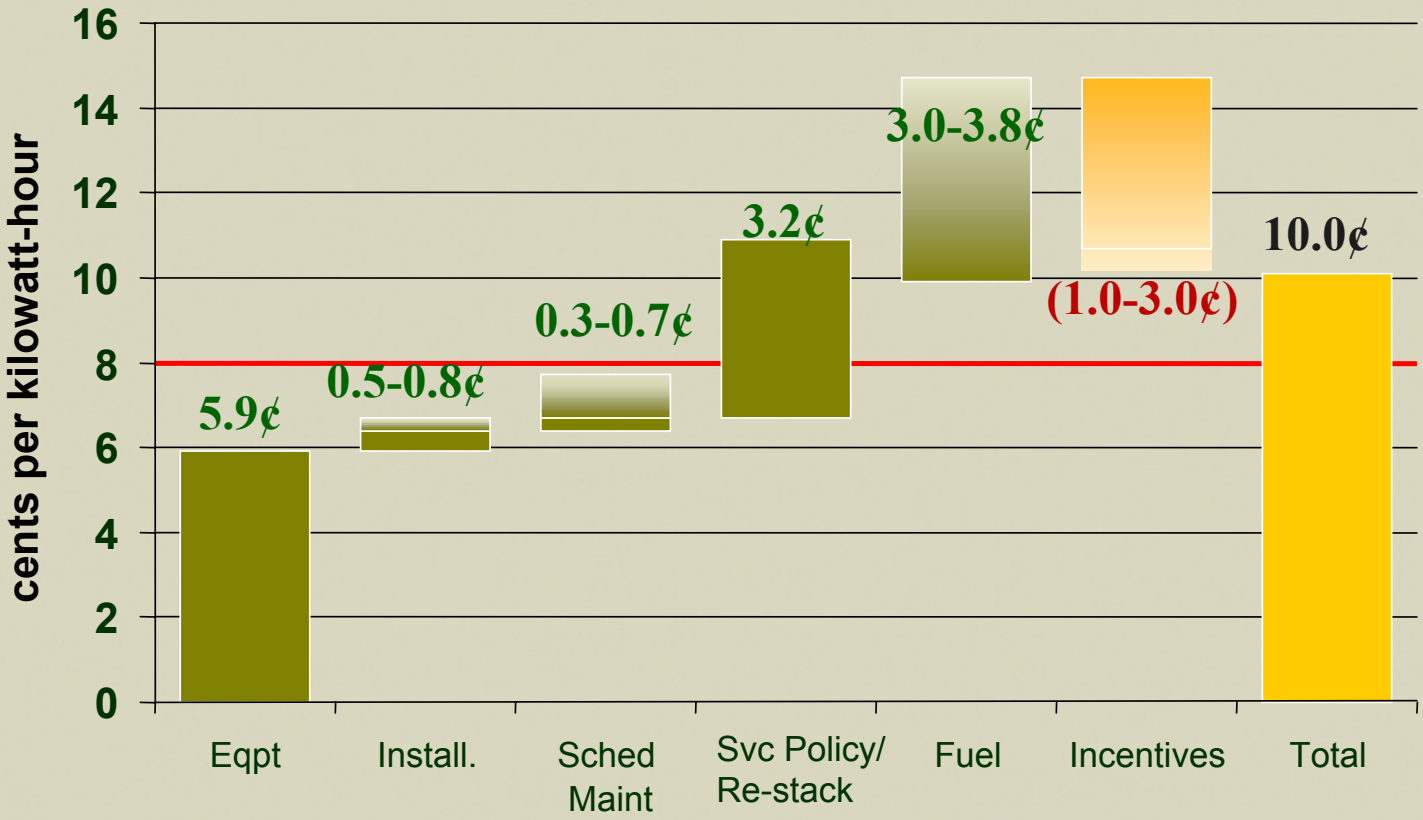
# Incentive Programs in CA - Bridging the First Cost Gap

| Program | Sponsoring Agency | Funds (MM$/yr) | Eligibility Criteria | Incentive Structure |
|---|---|---|---|---|
| **Self Generation Program** | **CA Public Utility Commission** | **$125 through 2004** | ■ **Fuel cells**, photovoltaic, wind, turbines, engines<br>■ **Up to 1 MW**<br>■ **Grid connected**<br>■ **Cogen heat recovery**<br>■ Commercial sales vs. demonstrations | **Direct Rebate:**<br>$4,500/kW for landfill gas or biogas fueled fuel cells up to 50% of project cosf<br>**$2,500/kW for nat gas fueled fuel cells up to 40% of project cost** |
| Emerging Renewables Buy Down | CA Energy Commission | $101 | ■ Photovoltaic, small wind solar thermal, and fuel cells *using renewable fuels*<br>■ Projects up to 1.0 MW<br>■ 5-yr equipment warranty | Direct Rebate:<br>$4,500 /kW up to 50% of total cost |
| **Technology Advancement** | **SAQMD** | **$20MM** | ■ **Co-funding of clean air technologies (fuel cells)** | **$100,000-$1,000,000 grant awards** |
| Public Leadership Solutions for Energy Fund | CA Power Authority | $1000MM initially | ■Federal, state and local public agencies, community colleges and school districts | 4.5-5% financing for agencies to undertake DG or energy efficiency projects |

# United States Federal Programs – Enabling Deployment in Other States

- Department of Defense Climate Change Program
  - $2.8MM, 2003
  - $1,000/kW rebate
  - Administered by DOE NETL
  - June 03 solicitation
  - September 03 awards
  - www.dodfuelcell.com/climate/index.html
- Federal Energy Bill
  - 35% tax credit for fuel cells being proposed

# Cost of Electricity in CA with Incentives: DFC300

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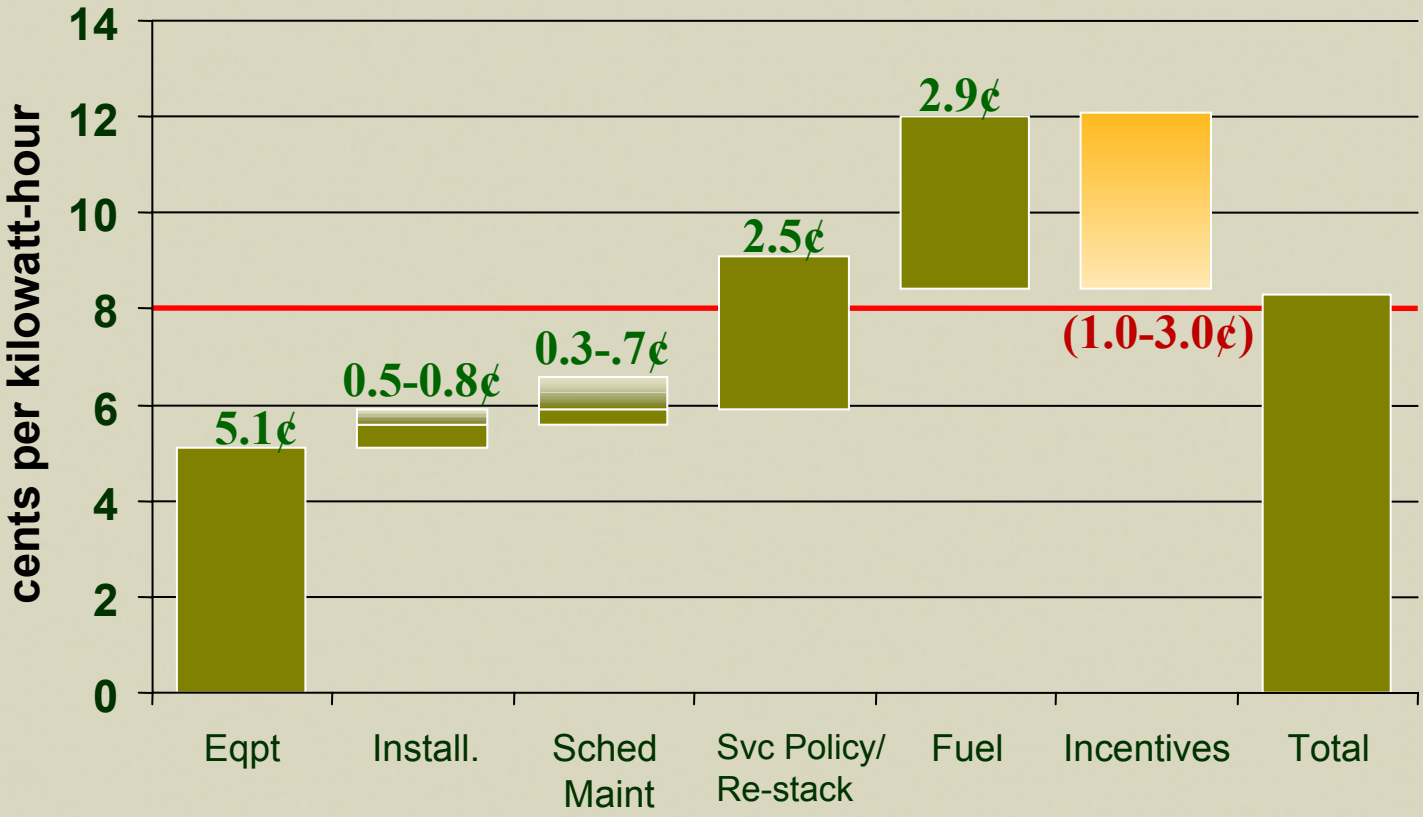
# Cost of Electricity in CA with Incentives: DFC1500

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- *Fuel cost = $4.00 /MMBtu*

# Driving Cost out Fuel Cell Manufacturing Process

## Established Manufacturing Processes

### Tape Casting

### Sintering

### Lamination

## Readily Available Materials

- Stainless Steel
- Nickel
- Ceramic Powders
- Carbonates (common minerals)

## Cost Reduction

- Manufacturing Volume
- Elimination of First Costs
- Performance Improvements
- Manufacturing Improvements
- 25-35% Realized to Date

# FuelCell Energy® Stationary Power Plants – Ready Today

- **Established technology, defined product lines**
- **Economically viable (with incentives) near-zero emissions technology in CA and NY**
- ***Ability to leverage existing natural gas infrastructure and still deliver environmental benefits associated with H2***
- **Well-defined end markets**

# A Powerful Opportunity

Distributed Energy Generation

FuelCell Energy